Case Study: The Search for Malaysian Airlines Flight 370

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Key words: aircraft search, ultra-deep survey, deep-tow system, Indian Ocean.

SUMMARY

Even today, hydrographic surveys can reach the boundaries of what is technical possible and project sizes as presented in this case study will push our ingenuity. The size-challenge can be defined by the extent of the project area, the water depth, the number of vessels/equipment involved, the data Volume or all of the above.

On 8 March 2014 the Malaysian airplane MH370 scheduled on a flight from Kuala Lumpur to Bejing with 239 people onboard went missing. This tragedy started a marine search and rescue mission, which turned later into the largest aircraft accident investigation in history. This case study presents a summary of the underwater search of this investigation.

The mainly uncharted search area in the southern Indian Ocean of 120.000 square kilometres reaches water depth up to 6.000 meters. The operation was planned in 3 phases: a deepwater multibeam survey to map the seafloor and enable a detailed search, the detailed survey to find the aircraft, and at last a recovery survey. Fugro was involved with four vessels in Phase 1 and 2 of the project.

Main challenges for the operation were:

- Size of the investigation area,
- Remote location of the search zone and its fairly unknown morphology,
- Water depth of up to 6.000 meter,
- Weather condition in the Indian Ocean with recorded heave up to 17 metre,
- Data Volume (reaching Petabytes) to be processed and a requirement to enable quick access to data for processing centres in various locations,
- Technology requirements, including deep sea rated AUVs and deep-tow systems.

1. INTRODUCTION

On 8 March 2014 the Malaysian airplane MH370 scheduled on a flight from Kuala Lumpur to Bejing went missing. On board the aircraft were 239 people. A marine search and rescue mission was started shortly after the disappearance, which turned later into an aircraft accident investigation to understand the circumstances leading to the tragedy and hopefully bring closure to the families.

The case study will present a summary of the underwater search of this investigation.

3. PROJECT OVERVIEW

3.1. The Search Area

The Australian Transport and Safety Bureau (ATSB) is leading the search and recovery operation in the southern Indian Ocean. One of the first steps of the investigation was the identification of the most-likely location of the missing aircraft. Available information and simulations were studied and produced a probability heat map of the aircraft location (Figure 1), which was used to specify the search area.

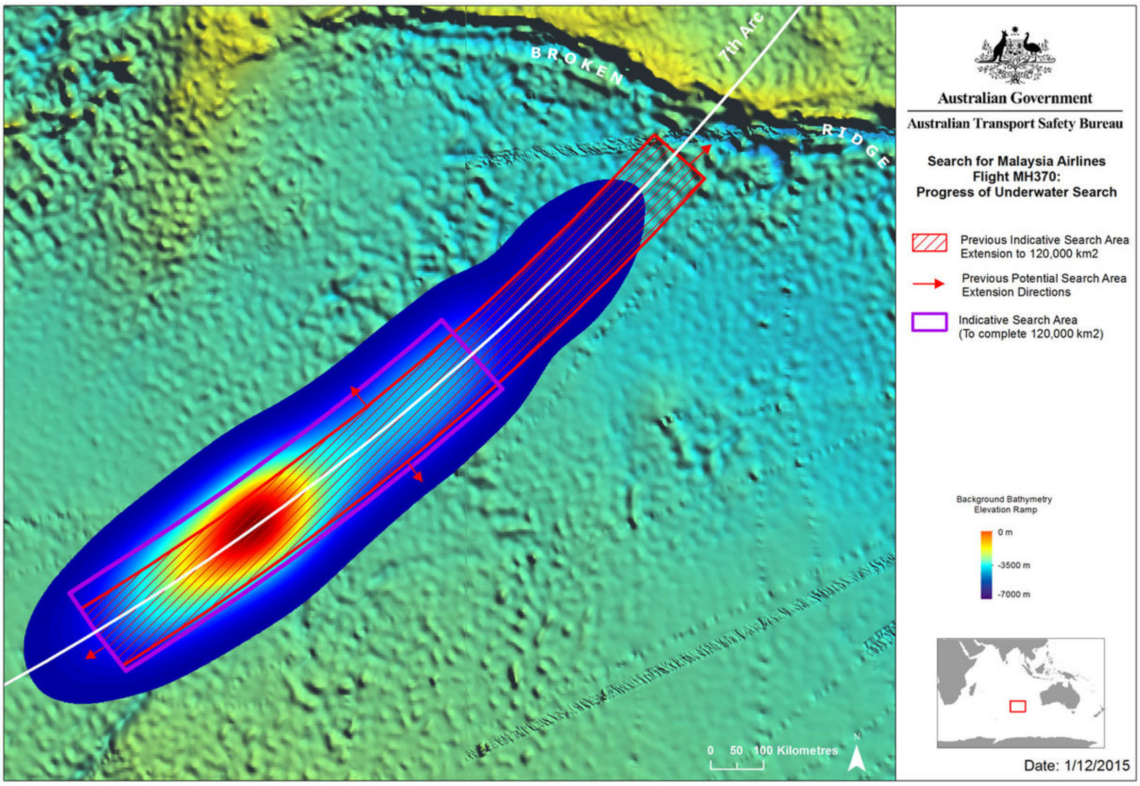

Figure 1: Outline of the 120.000 km^2 search area based on probability location of the aircraft; scale from blue (low probability) to red (high probability) (source: ATSB [1])

The underwater search area is in a remote location approximately 1.000 to 1.500 nautical miles west of Freemantle, Australia; a sailing time of 4 to 6 days at 10 knots to reach the location by survey vessel.

The size of the search zone measures 120.000 square kilometres with water depth up to 6.000 meters. The morphology of the seafloor was relatively unknown previous to the search operation. Satellite radar altimetry data gave an indication of the expected water depth and aided with the planning.

3.2. Search Parameters

From previous aircraft accidents it is understood that an aircraft can break up on contact with the water surface, e.g. the accident of the AF447 flight in June 2009 revealed a debris field of 600 meters by 200 meters on the seafloor with one of the turbine engines as the largest located piece (BEA [2]). This experience was used to specify the parameters for the MH370 search. The operation had to be designed to identify debris fields with individual maximum target size of 2 square meters, while full coverage of the entire priority search area was required.

3.3. The Survey

The operation was split into three phases (Table 1) and started with the deepwater multibeam echosounder investigation to map the seafloor with a hull-mounted Kongsberg EM302 system of the Fugro Equator, which was later joined by 3 further Fugro vessels. The bathymetry revealed a challenging morphology with underwater volcanoes and canyons, e.g. at the Greelvink Fracture Zone an up to 10 kilometre wide canyon was observed with an almost 1 kilometre high perpendicular wall.

Table 1: Overview of Survey Method per Phase

Survey Phases	Method	Coverage rate
Map the seafloor to enable save mission planning for detailed search	Deepwater multibeam survey with hull-mounted echosounder	1200 km^2/d, Cross track resolution 104 m
Detailed survey to identify the aircraft and map/photograph the debris field	Deep-tow (DT) & AUV survey; with multibeam echosounder, side scan sonar, subbottom profiler, camera, USBL positioning,	DT: 133 km^2/d and cross track resolution: 0.7 m; AUV: 17 km^2/d and cross track resolution: 0.1 m
Find and recover (Phase not started)	ROV survey	24 km^2/d and cross track resolution 0.1 m

Based on the bathymetry the detailed survey plan was designed. The deep-tow system was selected as primary solution for the second phase. The altitude of the deep-tow system was set at 150 meter above the seafloor to ensure the required resolution and maximal possible coverage. This resulted in a towed distance of approximately 9 kilometres behind the vessel (Figure 2), which limited the manoeuvrability of the spread. As secondary system an AUV (Echo Surveyor VII, a Kongsberg Hugin 1000) was selected to cover the areas that could not be reached by the deep-tow system and for detailed inspections of recorded targets of interest. The AUV was deployed from the stern of the vessel on pre-programmed missions flown at 100 meters altitude, hence the necessity of the high resolution bathymetry from the first phase of the project.

The deep-tow systems as well as the Echo Surveyor VII were depth rated to 6000 meters. The systems were equipped with state-of-the-art sensors: Edgetech 75kHz side scan sonar, Kongsberg EM2040 multibeam echosounder, Edgetech subbottom profiler, cameras, hydrocarbon sniffer (only at the beginning of the investigation) and positioning systems such as Doppler Velocity Log (DVL), altimeter, sound velocity sensors, HAIN motion sensors and Ultra Short Baseline (USBL) systems (HiPAP 101 for the deep-to systems, HiPAP 501 for the AUV respectfully).

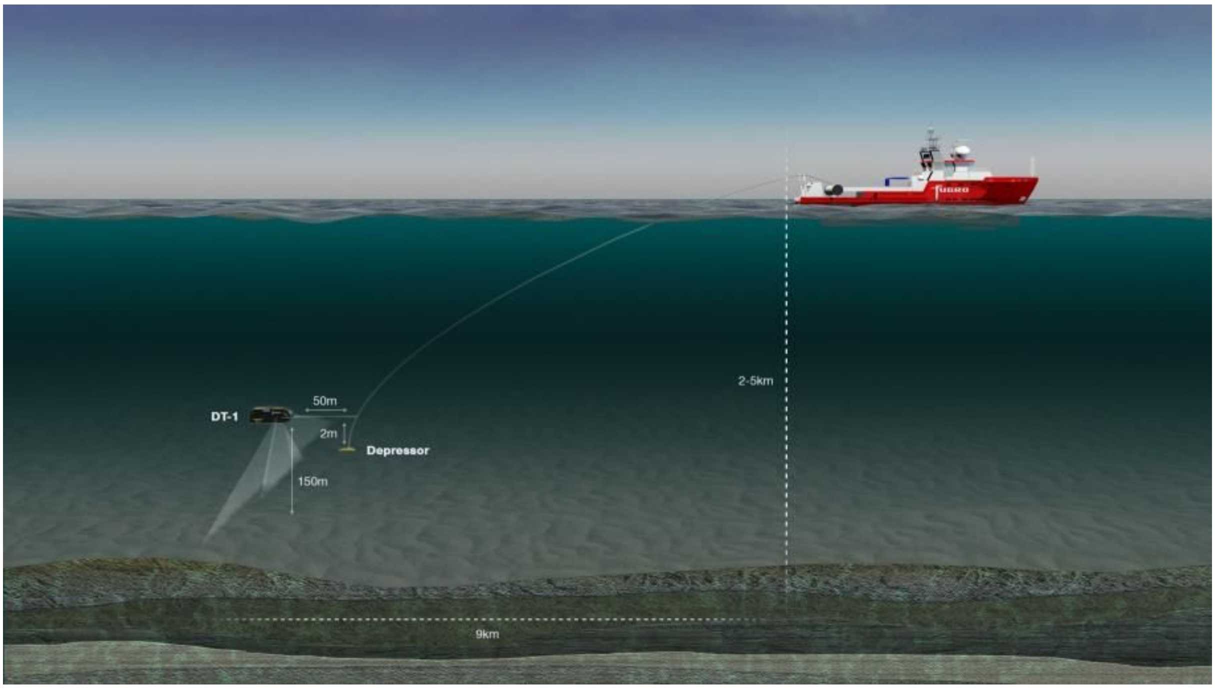

Figure 2: Schematic representation of the deep-tow system of the Fugro Equator (source Fugro [3])

Data from the deep-tow system was transmitted directly via an umbilical to the vessel, while the data onboard the AUV was recorded onboard the vehicle an uploaded after each mission. Missions were limited by battery power to approximately 30 hours. Data was copied immediately to a secondary server system for back-up and then transmitted via satellite systems to shore in near real time to enable access to the authorities to all information and allow coordination and control of the operation. Processing of the data was split over various processing centres to increase efficiency. The data was reviewed by minimum of four independent geophysicists (ATSB and Fugro) to ensure that no target was missed.

4. IMPLICATION OF THE REMOTE LOCATION

It was mentioned before that the search area was defined in a remote location. There are two main challenges with the remote location: number one is the distance to the nearest port and hence long sailing times, number two is that so little is known about the investigation area.

4.1. Distance to shore / Sailing time

Vessel mission periods are limited by the fuel consumption and food supplies that a vessel can carry. During the MH370 search operation Fugro vessels with a length between 65 and 93 meters were involved in the project. Even though missions were usually planned for maximum duration of each vessel, effective survey time was always limited by the sailing time from and to the search area, which averaged 10 to 12 days per mission. Using up to four survey vessels attempted to minimise this impact on effective survey time.

The long distance to shore also has an impact on each interruption of the operation. It was clear that unplanned mission breaks had to be avoided. Therefore all vessels had a doctor onboard and remote tele-medicine to reduce the likelihood of medical emergency breaks. Even though the medical risk was considered it could not be totally avoided. In the 2 years operation there were 2 emergency port calls due to illnesses, though no injuries.

Another risk was exposure to weather extremes. The risk was mitigated by 6 hourly weather forecasts to ensure safe mission planning. Though equipment could be recovered onboard in time, there was no shelter close by and therefore the vessels had to stay out at sea. During the project there were 4 tropical cyclones at the search area which resulted to largest recorded wave heights of 17 meters, and wind up to 78 knots (~150 km/h).

Not only weather extremes were a limitation to the survey also standard wave heights in the Indian Ocean had an impact on the operations as the AUV had to be launched and recovered on a regular basis. If wave heights increased above the safe operation limits missions had to be postponed until safe operations were possible again. During the project a new launch and recovery system was installed onboard one of the vessels used during the survey, the Harvila Harmony, which increased the AUV weather window to wave heights of up to 3.5 meters.

4.2. Unknown of the investigation area

Even though hydrographic surveys have been carried out for centuries the main research areas of interest are near to shore in national territories or along popular shipping routes. In general, the further the operation area is away from shore the less information is available. Also satellite radar bathymetry becomes more and more available the details of the collected data reduce with increasing depths. The MH370 search area is not only located far away from shore, but also in deep water, which resulted in sparse available information before operations started. This made it necessary to commence the operations with the mapping of the survey, before the detailed search could start to reduce the likelihood of losing the survey equipment.

5. CLOSE-OUT

At the time of the finalization of this paper (31. August 2016) flight MH370 has not been located, but decision has been made that with completion of the priority search zone the underwater search will come to an end. The tragedy remains a mystery (for now).

However, data that was collected during the search mission will be made available and might support future studies on tectonics or other earth science topics and increase our understanding of the earth, especially of the seafloor of the Indian Ocean.

Experiences gained during the operation will assist in future projects, e.g. the newly designed launch and recovery system will make operations safer and remote processing becomes a common practice.

REFERENCES

Journal articles:

[1] ATSB Transport Safety Report: *MH370 - Definition of Underwater Search Area,* AE-2014-054, 3 December 2015.

[2] BEA: *Final Report - On the accident on 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight AF 447 Rio de Janeiro – Paris,* F-GZCP 1st June 2009 (*Update: 27 July 2012).*

Links:

[3] http://www.fugro.com/mh370/media-library, 31.08.2016

BIOGRAPHICAL NOTES

Melanie Barth has studied geology at TU Clausthal (Germany) and finished with a master degree in geology and paleontology in 2000. Main subjects of her degree were hydrogeology, engineering geology and geochemistry. Her first steps into the offshore world occurred during the first assignment as project engineer for marine cable route surveys at NSW (Norddeutsche Seekabelwerke GmbH & Co. KG in Nordenham, Germany). Until 2004 she was responsible to subcontract, supervise and evaluate marine cable route surveys for projects all over the world. In 2004 she moved to C&C Technologies Inc. (Lafayette, LA), where she worked as marine geologist mainly in the Gulf of Mexico. Projects included AUV deep water projects for the mapping of chemosynthetic communities, but also pipeline reconnaissance surveys after hurricane Catrina in 2005. In May 2007 she started at Fugro Survey BV. (Leidschendam, Netherlands) as Processing and Reporting Manager, and built up the department for data processing, reporting and QC for positioning, construction support and geophysical projects. Since May 2014 she has the position of Delivery Excellence Manager at Fugro. Her task is to drive Excellency in the various Fugro survey offices, which includes the improvement of quality and timeliness of deliverables as well as to increase the effectiveness in the reporting process by introducing standard tools and processes.

Member of AGU (American Geophysical Union) and EAGE (European Association of Geoscientists and Engineers).

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